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(54) Abstract Title
Control of liquid boiling appliance

(57) An automatic water boiling appliance heats the water to a predetermined sub-boiling temperature and then activates a timer to time out a further heat-to-boiling period after which the heating element 1 of the appliance is switched off An accurate bimetallic cut out 2 is used to sense a water temperature of, say, 94°C. When the cut-out operates at 94°C, in one embodiment a time current selected cut-out 4 maintains the current supply to the heating element 1 for a redetermined further period, and in another embodiment an auxiliary heater (11, Figure 2) is energized to initiate the operation of a thermal relay which cuts out after a predetermined further time period. The system automatically compensates for voltage variations and is usable all over the world despite the variations which occur in the boiling temperature of water. Means can readily be provided to adjust the further heat-to-boil time period so as to give a long or short boil as desired.

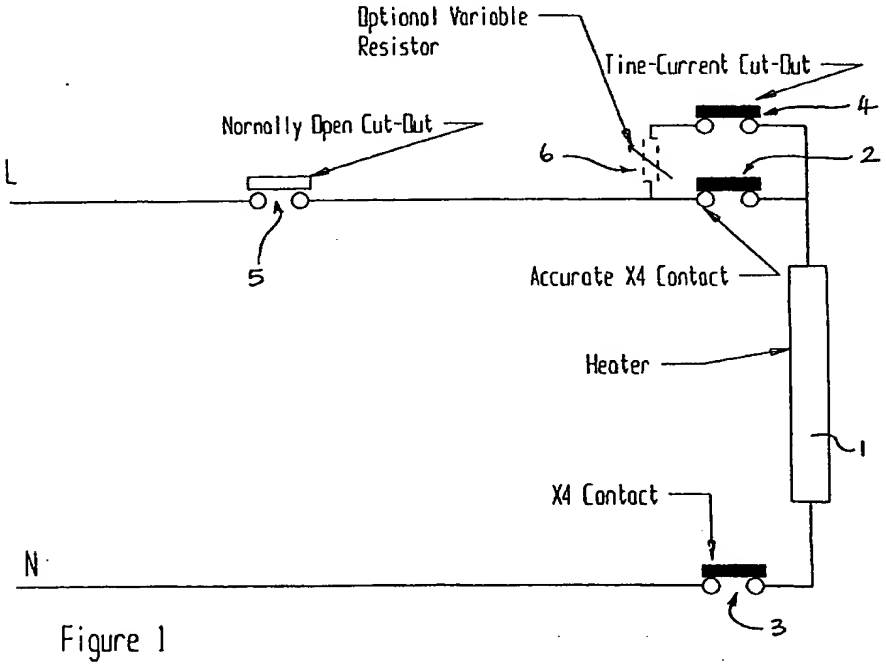

Figure 1

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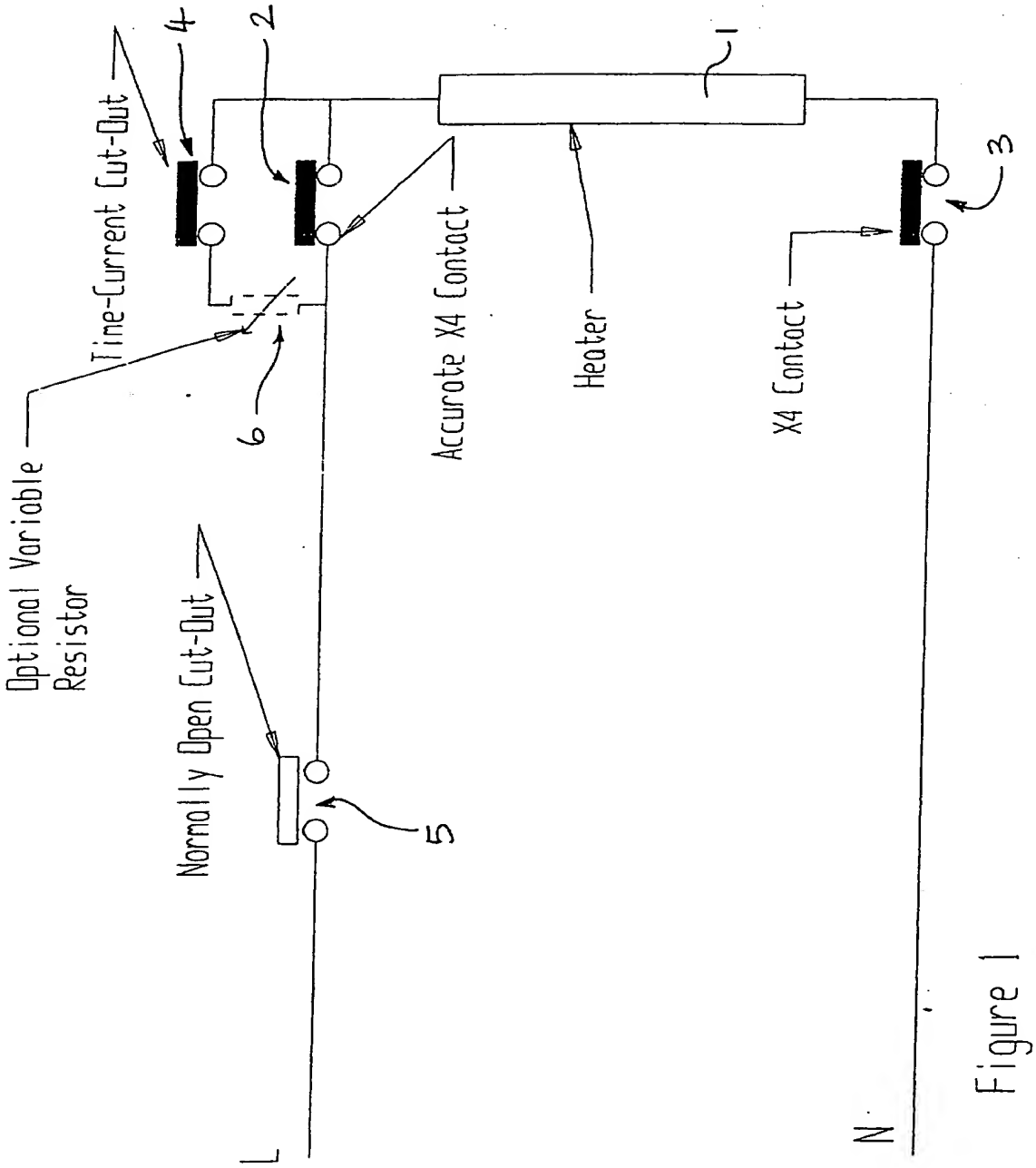
Time-Current Cut-Out
4
2
1
3
Accurate X4 Contact
Heater
X4 Contact
Optional Variable Resistor
6
Normally Open Cut-Out
5
L
N

Figure 1

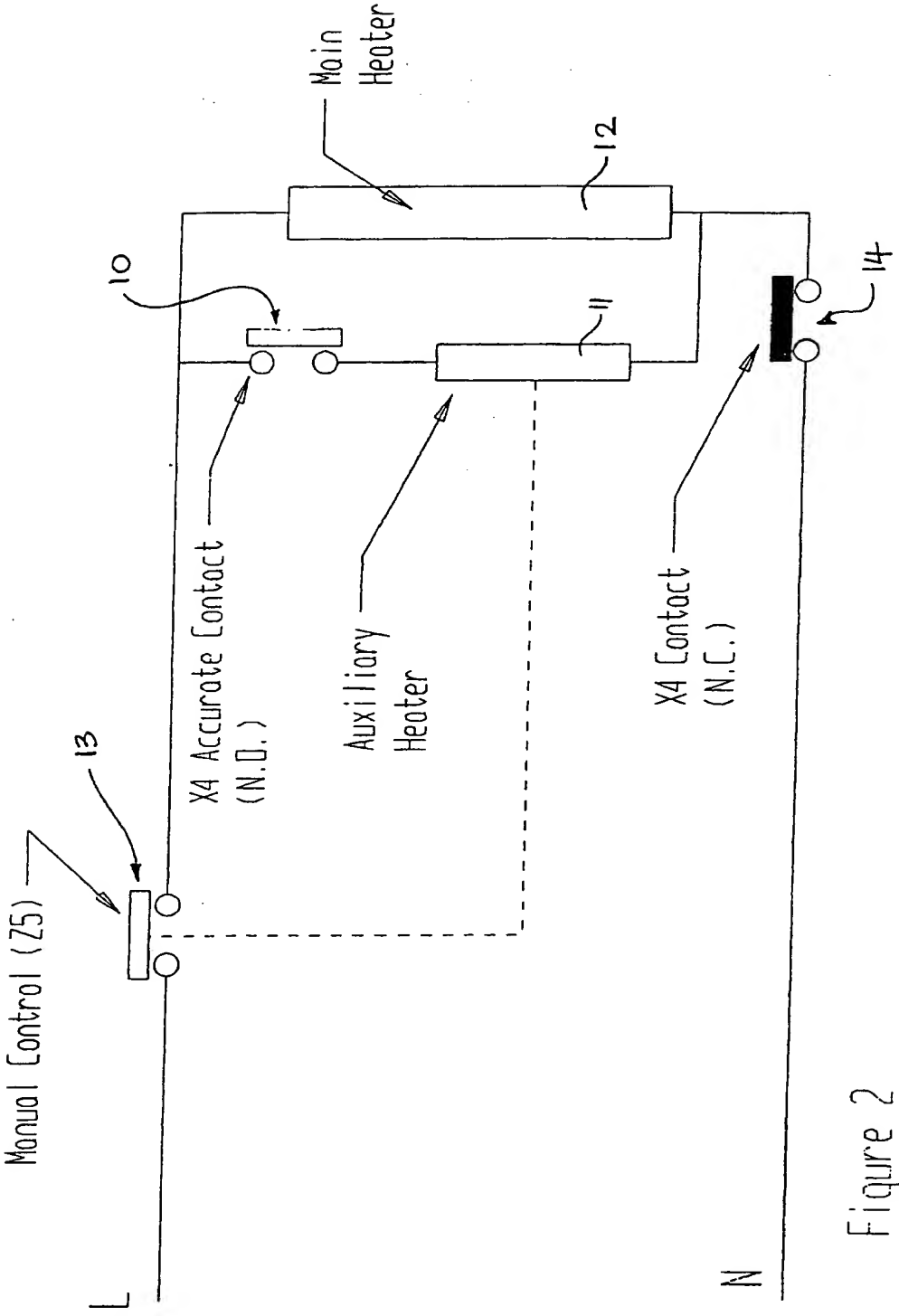
Main Heater
12
10
11
14
X4 Accurate Contact (N.O.)
Auxiliary Heater
X4 Contact (N.C.)
13
Manual Control (Z5)
L
N

Figure 2.

IMPROVEMENTS RELATING TO LIQUID HEATING APPLIANCES

Field of the Invention:

This invention concerns improvements relating to liquid heating appliances, particularly though not exclusively water heating appliances such as kettles and hot water jugs for example, and is more particularly concerned with the means whereby such appliances are switched off or subjected to reduced heating when liquid in the appliance is heated to boiling.

Background of the Invention:

In the field of electric water boiling appliances, domestic kettles and hot water jugs for example, it is conventional to provide the appliance with a steam sensor which detects the generation of steam when water is boiled in the appliance, the steam sensor then determining the switching off of the appliance. The steam sensor commonly comprises a thermally-responsive member such as a bimetal or shape memory effect device for example, the thermally-responsive member being coupled to a switch in the appliance so as to open the switch when the member responds to the generation of steam when water in the appliance is heated to boiling. Examples of such steam sensors are described in GB-A-2 212 664 and GB-A-2 331 848.

Boil sensing can also be effected by responding to the stabilization of the liquid temperature as the liquid approaches and attains boiling. This has

been utilized or proposed to be utilized in electronic kettle controls wherein a temperature sensor, a thermistor for example, provides a temperature-responsive output signal which stabilizes when the liquid temperature reaches its boiling point. By monitoring the rate of change of the sensor output, the boiling point can readily be detected. An example of such an electronic kettle control is described in GB-A-2 185 161.

Kettles and hot water jugs are commonly provided with a control, known as a dry boil or element protector control, which is designed to protect the heating element of the appliance against excessive temperatures arising for example on account of the appliance being switched on without first being filled with water. It has further been proposed to detect the heating of a kettle or hot water jug to boiling by associating an enclosure with the dry boil control, the enclosure filling with water when the appliance is filled and the generation of steam when the water boils causing the water to be expelled from the enclosure so as to give rise to a quasi dry boil condition therein which can be sensed by the dry boil control. Such an arrangement enables dry boil protection and automatic, switch-off on boil, operation to be achieved with but a single control. Examples of such enclosure proposals are disclosed in GB-A-2 265 071 and GB-A-2 283 155.

The enclosure proposal abovementioned is attractive not only because it requires on a single sensor, but also because it obviates the requirement for a control which is exposed to steam. As is well known, water and electricity

represent a potentially dangerous mixture and much effort is made in the design of steam controls to ensure that electrical parts are well separated from parts liable to be wetted by condensed steam. The steam controls that are currently available from us are entirely safe in normal operation, but the possibility always remains that a dangrous situation could arise if an appliance is misused.

Objects and Summary of the Invention:

The object of the present invention is to provide yet another means of switching off or reducing the power supply to the heating element of a liquid heating appliance when the liquid in the appliance has been heated to boiling.

According to the present invention, a thermally-responsive control for a liquid heating appliance comprises a sensor responsive in use of the appliance to the liquid temperature reaching a predetermined sub-boiling temperature, and means responsive to the sensor for switching off or reducing the power supply to the heating element of the appliance some time period after operation of the sensor, such time period being sufficient for the liquid temperature to have been elevated from said sub-boiling temperature to its boiling point.

The invention thus proposes an arrangement wherein a sensor provides an output at a liquid temperature which is, say, a few degrees below boiling

and this initiates a limited further heating period sufficient to bring the liquid up to its boiling point.

The present invention stems from our appreciation that the time taken to boil water in a kettle or hot water jug from a temperature of around 94°C, say, is sufficiently constant to be used as a means to switch off the appliance when it boils. We have found that the difference between the shortest time (eg. with a 3kW kettle filled to minimum) and the longest time (eg. a 2.2kW kettle filled to maximum) is of the same order as that seen between switch off times on a conventional kettle provided with a steam control, depending on the fill volume of the kettle. Generally, a kettle with less water takes longer to switch off a steam control after the water boils than does a full kettle, because of the time it takes to fill the kettle body with steam before the steam is vented from the kettle body onto the steam control. The time variation can be as much as 15 seconds between the fastest and the slowest. The temperature of 94°C abovementioned is chosen to be below the lowest boiling point seen in most parts of the world, it being appreciated that the boiling temperature of a liquid is dependent upon atmospheric pressure and thus upon altitude, and the invention is not limited to 94°C being the aforesaid predetermined sub-boiling temperature.

For sensing the liquid temperature and initiating the final heating-to-heating period an accurate bimetallic actuator can conveniently be used, preferably a dished disc bimetal of snap-acting type which has a good

action, is relatively simple to set to a precise operating temperature by determination of the amount of dishing to which the disc is subjected in manufacture of the actuator, and can readily be arranged in good thermal contact with the liquid whose temperature is to be sensed. In this latter connection, the bimetallic actuator could be arranged to monitor the liquid temperature more or less directly, for example in the case of an appliance utilizing a thick film heating element by being in close thermal contact with a part of the heating element which carries no heating tracks and therefore is substantially at the temperature of the liquid being heated, or could alternatively monitor the heating element at a location traversed by one or more heater tracks in which case the temperature setting of the actuator would be a higher setting which takes account of the difference between the track temperature and the liquid temperature.

The final heat-to-boiling period could be determined by an electronic timer chip or by any convenient kind of electromechanical timer arrangement, for example a timer as described in GB-A-2 266 625, but conveniently is constituted by a current sensitive bimetallic actuator which will operate after a predetermined time period when carrying a particular current. Such "time current selected" actuators conventionally find application in the automotive industries as protectors for small electric motors.

The final heat-to-boiling period may advantageously be arranged to be adjustable. In different regions around the world, different cultures demand

different boil times before an automatic appliance switches off. In some cases this stems from poor water quality where a prolonged boil period is required to ensure sterilization, whereas in other areas a short boil is preferred to reduce the build up of steam and condensation. Where a time current selected bimetallic actuator as abovementioned is used to determine the heat-to-boiling period, this period can readily be adjusted by adjustment of the through current in the actuator, for example by provision of an adjustable resistance in circuit with the actuator. In a thick film heating element situation, such an adjustable resistance could be integrated with the heating element. Electronic and electro-mechanical timers conventionally incorporate means whereby their timing period may be selectively adjusted.

The above and further features of the present invention are set forth with particularly in the appended claims and will be well understood from consideration of the following description of exemplary embodiments of the invention which are shown in the accompanying drawings.

Description of the Drawings:

Figure 1 is a schematic circuit diagram of a first embodiment of the invention; and

Figure 2 is a schematic circuit diagram of a second embodiment of the invention.

Detailed Description of the Embodiments:

Referring first to Figure 1, schematically shown therein is the heater 1 of a liquid heating vessel such as a domestic kettle or hot water jug for example with associated controls which might for example be built into an integrated control cum power supply inlet connector unit such as our X4 product which is described in WO-A-9954903. As shown, the heater 1 is supplied through two bimetal-actuated contact sets 2 and 3 each of which is arranged in a different pole of the power supply. The bimetal associated with contact set 2 is set accurately to operate the contacts 2 at a temperature of 90 - 94°C and, as mentioned hereinbefore, is preferably a snap-acting disc bimetal rather than the bimetal that we have conventionally used in our X-series controls since a simple disc bimetal gives a better action, is simpler to set more accurately and gives a good thermal contact with the heating element surface when set at these lower temperatures. Connected electrically in parallel with the contact set 2 is a thermal cut-out 4 which has been selected to open its contacts after a preset time when carrying a particular current. Such a control is commonly called "time current selected" and is normally used by the automobile industry to protect small electric motors. Connected in the supply to this whole arrangement is a further thermal cut-out 5, this one being of the type that closes its contacts on rising temperature ("make on rise") and is normally open circuit when cold. This second cut-out 5 has a mechanical means to momentarily close its contacts. The cut-outs 4 and 5 may for

example be Q switches as made and sold by us, such switches being substantially as described in GB-A-2 124 429.

The action of the Figure 1 arrangement is as follows: To switch on the contacts of the normally open cut-out 5 are momentarily closed and current is supplied to the heating element 1. Current heating of the bimetal of cut-out 5 raises its temperature, and the contacts remain closed. The water in the vessel heats until the accurately set bimetal associated with contacts set 2, which is sensing water temperature through the base of the vessel (the thick film steel plate of heater 2 for example), reaches its operating temperature (eg. 94°C) and opens its contacts 2. The heater current now passes through the time current selected cut-out 4, which, after its preset time (eg. 30 seconds) opens its contacts and de-energises the heater 1. Because current is no longer flowing through the normally open cut-out 5, its bimetal cools and opens its contacts, thus ensuring that no further current can flow through the heater 1 when either the X4 bimetal 3 or the time current selected cut-out 4 resets.

To reboil, the contacts of the normally open cut-out 5 are momentarily reclosed by means of a mechanical push button (not shown) which also attempts to reset the bimetal associated with contact set 2. If this bimetal is resettable, ie it is below 94°C, then the above cycle is repeated. If the bimetal associated with contact set 2 is still above its set point, then it will not reset and current will flow immediately through the time current selected cut-out 4 which, after a time which is long enough to reboil the water (the water must

already be above 94°C), opens its contacts and de-energises the heater. Note that, depending on how long it is since the water boiled when a reboil is attempted, the time current selected cut-out 4 may still be hot and will have a time to break which is shorter than the preset time. This ensures that attempting to reboil water which has just boiled will not result in an excessively long period of boiling before switch off.

Preferably with this arrangement the time current selected cut-out 4 is mounted so that it senses an ambient temperature which is close to the water temperature, which will ensure that its time to break will remain consistent and not be affected by variations in room temperature. The time to break for such a control will also depend on supply voltage variations, being longer at lower voltages. This reflects the reduction in element power at reduced voltages which also results in a longer boil time. Hence some measure of voltage compensation is inherent in this proposal.

As in a conventional X4 control, the contact set 3 and its associated bimetal provides a secondary protection function to ensure that in the event of failure of the live side components 2, 4 to switch off the heater in a prolonged boil or a dry boil situation, the element 1 can still be switched off at a safe temperature.

Also shown in Figure 1 is an adjustable resistor 6 which enables the current through the time current selected cut-out 4 to be selectively adjusted

for the purpose of adjusting the time-to-boil period as determined by the cut-out 4.

The above description assumes that the accurately set bimetal associated with contacts set 2 is located on an unheated area of the base of the vessel, in order that it can sense the water temperature more or less directly. This may not necessarily be so, and the bimetal could be placed on a heater track of a thick film element in which case it would be set at a higher temperature than the 90-94°C abovementioned which reflected the offset between the track temperature and the water temperature. In this case the bimetal (and track) temperature would fall rapidly to the water temperature on switching off the heater, thus ensuring that the bimetal could be easily reset, either mechanically on switch on or automatically by having a remake temperature above 100°C which additionally would remove the need for a mechanical reset method for the bimetal.

Referring now to Fig 2, in this control system, which is based as above on our X4 control, the accurately set bimetal is associated with normally open contacts 10 which are in series with an auxiliary heater 11, rather than with the main heater 12. The auxiliary heater 11 is arranged so that it can heat the bimetal of a manual control 13 such as our J1 or Z5 controls, whose contacts control the power supply to the whole heater. This arrangement is substantially as described in GB-A-2 273 007 and is basically a thermal relay. The auxiliary heater 11 may be a separate component, such as a thick film

resistor, or, preferably, the main heater 12 is a thick film heater and the auxiliary heater 11 is printed as a separate track on the same substrate. In this case the auxiliary heater track would preferably be printed to have a matt black surface to enhance the heat radiation properties and give better controllability and repeatability.

The action of the Figure 2 arrangement is as follows: The manual control 13 is switched on and the main heater 12 is energised. When the accurately set bimetal reaches its operating point it closes its contacts 10 and this energises the auxiliary heater 11. Power continues to flow to the main heater 12. After a time delay, the manual control 13 operates as a result of its bimetal being heated by the auxiliary heater 11 and this de-energises the whole heater. Once the manual control bimetal has cooled slightly it may be reset (especially if it has the adjustable push rod feature described in our British Patent Application No. 9904391.1) and the water may be reboiled. As in the first embodiment, the heat output of the auxiliary heater 11 is voltage dependent and will give some measure of voltage compensation by taking longer to operate the manual control 13 at lower voltages. The time to switch off is set by the power output of the auxiliary heater 11 and its distance from (or amount of thermal coupling with) the bimetal of the manual control 13.

As in the first embodiment, the arrangement of Figure 2 includes a second set 14 of contacts and, in a variation of the Figure 2 arrangement, the auxiliary heater 11 formed on a thick film element, may be arranged to heat

the bimetal associated with this second set of contacts in order to de-energise the heater. The power output of the auxiliary track would be such as to raise the bimetal from its normal running temperature to its break point in the required time. In this case some mechanical arrangement (not shown) would need to be provided to allow the system to be reset. In a further variation of this arrangement the accurately set bimetal associated with contact set 10 may be arranged to initiate the timing cycle on an electronic or electromechanical timer, whose output determines the power supply to the heater.

In both the above arrangements a further feature may be provided for added customer appeal. In different areas around the world different cultures demand a longer or shorter boil time. In some cases this is as a result of poor water quality where a prolonged period of boil is needed to ensure that the water is sterilised. A short boil is preferred in some areas to avoid steam and condensation build up in kitchens. Providing such boil time variation with a conventional steam actuated boil control is difficult. Short boil times can lead to a failure to boil at all. Long boil times are normally achieved by restricting the flow of steam to the control and such restricted passages can become blocked by scale or condensation, leading to a failure to switch off at all. Because of this, steam activated boil controls tend to be sent in a conservative manner to give a reasonable cut-off under most conditions of use.

To achieve a variable boil time with the described arrangements is simply a matter of adjusting the time delay of, in the first embodiment, the

time current selected cut-out 4 or, in the second embodiment, the thermal relay constituted by auxiliary heater 11 and manual control 13 (or second contacts set 14 and its associated bimetal).

To adjust the time to cut off for the time selected cut-out 4 of the first embodiment it is necessary to change the current passing through it. Because of the relatively long times needed, time current selected cut-outs are in fact quite sensitive to changes in current, and so a variable resistor placed in series with the control and capable of carrying the whole heater current and of varying it by around 1 amp (10%), would give a useful variation in cut-off time. Such a resistor could be printed alongside the tracks of a thick film heater, to ensure that the power it dissipated was efficiently used to heat the water. The power connections to that resistor could be in the form of a sliding contact, such as is described in WO-A-9954903.

To adjust the time for the thermal relay/manual control of the second embodiment, the power of the auxiliary track 11 may be adjusted by including a variable resistor in series with it, as in the previous case. Alternatively, the thermal coupling of the auxiliary heater 11 to the bimetal of the manual control 13 may be mechanically adjustable, by moving the control towards or away from the heater for example or, preferably, by partially occluding the bimetal. Such occlusion would be easy to achieve by moving a shutter across the face of the Z5 bimetal for example. The shutter would be linked to a control knob accessible from the outside of the appliance.

A further benefit of the second embodiment is that the switching on of the auxiliary heater track can be arranged to restore the element power to its level when the element was cooler. Most thick film elements use heater tracks that have, to some extent, a positive temperature coefficient of resistance. This is a natural consequence of the materials used, adds stability and increases the endurance of the track when dry boiled. It also reduces the power output of the element when hot. By adding the power of the auxiliary heater towards the end of the heating period, the power may be restored to near its initial level (aside from any initial inrush current when cold) to maintain the rate of heating the water. It may also assist the consistency of time to boil from the switching temperature of the first bimetal, and thus improve the perceived performance of the system.

Having thus described the invention in the foregoing by reference to specific embodiments, it is to be appreciated that the described embodiments are in all respects exemplary and that modifications and variations thereto are possible without departure from the spirit and scope of the invention. For example, in the Figure 2 arrangement, rather than utilizing the thermal relay constituted by auxiliary heater 11 and manual control 13, the advantages abovementioned of the provision of the auxiliary heater could be retained, but without interaction between the auxiliary heater and the manual control, and instead the operation of the control 10 could be arranged to initiate the heat-to-boil final heating period by initiating the operation of an electronic or

electromechanical timer arranged to determine the power supply to the heater. Furthermore, in addition to providing for adjustment of the further heat-to-boil period, or alternatively thereto, the temperature at which the further heat-to-boil period is initiated could be made selectively adjustable by use, for example, of an adjustable bimetallic sensor.

CLAIMS:

1. A liquid boiling appliance which, in operation, heats to a sub-boiling temperature whereupon a timing operation is initiated so as to continue heating for a set period sufficient to bring the liquid to boiling.

2. An appliance as claimed in claim 1 wherein said sub-boiling temperature is selected to enable the appliance to be used substantially in any part of the world and said period is selected in consideration thereof.

3. An appliance as claimed in claim 2 which is adapted for boiling water and wherein said sub-boiling temperature is around 90 to 94°C.

4. An appliance as claimed in any of the preceding claims wherein said sub-boiling temperature is detected by means of an appropriately calibrated bimetallic actuator.

5. An appliance as claimed in claim 4 wherein said bimetallic actuator comprises a dished, snap-acting, bimetallic disc.

6. An appliance as claimed in any of the preceding claims including a timer for determining said timing operation.

7. An appliance as claimed in claim 6 wherein the timer is a current-responsive device.

8. An appliance as claimed in claim 7 wherein said current-responsive device comprises a bimetallic actuator adapted to change state after a predetermined period of through current.

9. An appliance as claimed in claim 7 wherein said current-responsive device comprises a bimetallic actuator and an associated heater, the bimetallic actuator being adapted to change state after a predetermined period of current flow in the heater.

10. An appliance as claimed in any of the preceding claims including means to enable said sub-boiling temperature and/or said set period to be adjusted.

11. An appliance as claimed in any of the preceding claims wherein the determining of said sub-boiling temperature and said timing operation are effected in an integrated control device.

12. An appliance as claimed in claim 11 wherein said integrated control device further comprises a power inlet connector for the appliance.

13. A control device for an appliance as claimed in claim 11 or 12.

14. A thermally-responsive control for a liquid heating appliance, said control comprising a sensor responsive in use of the appliance to the liquid temperature reaching a predetermined sub-boiling temperature, and means responsive to the sensor for switching off or reducing the power supply to the heating element of the appliance a time period after operation of the sensor sufficient for the liquid temperature to have been elevated from said sub-boiling temperature to boiling.

15. A control as claimed in claim 14 for use in a water boiling appliance and wherein said predetermined sub-boiling temperature is around 90 to 94°C.

16. A control as claimed in claim 14 o4 15 wherein said sensor comprises a precisely calibrated, dished, snap-acting disc bimetal.

17. A control as claimed in any of claims 14 to 16 wherein the means for determining said time period comprises a time current selected bimetallic cut-out.

18. A control as claimed in claim 17 as dependent upon claim 16 wherein said precisely calibrated bimetal is arranged to determine the opening of a current path to the heating element of the appliance at said predetermined sub-boiling temperature, and said time current selected bimetallic cut-out is connected in parallel with said precisely calibrated bimetal so as to maintain a current path to the heating element for said time period after operation of said precisely calibrated bimetal.

19. A control as claimed in any of claims 14 to 18 including means enabling said predetermined sub-boiling temperature and/or said time period to be selectively adjusted.

20. A control as claimed in claim 19 as dependent upon claim 17 or 18 wherein an adjustable resistance is arranged to be connected in series with said time current selected bimetallic cut-out.

21. A control as claimed in any of claims 14 to 16 wherein the means for determining said time period comprises a thermal relay.

22. A control as claimed in claim 21 wherein said thermal relay comprises a bimetallic cut-out having or adapted to have associated therewith a heater operable to heat the bimetal to its contacts-open condition in said time period.

23. A control as claimed in claim 21 or 22 including means enabling said predetermined sub-boiling temperature and/or said time period to be selectively adjusted.

24. A control as claimed in claim 23 as dependent upon claim 22 wherein the degree of thermal contact between the bimetal of the bimetallic cut-out and said heater is adjustable for adjusting said time period.

25. A control as claimed in claim 24 wherein the spacing apart of the bimetal and the heater is adjustable.

26. A control as claimed in claim 24 wherein an adjustable shutter is provided for adjustably occluding the bimetal from the heat of the heater.

27. A control as claimed in claim 20 or claim 22 or in any of claims 23 to 26 as dependent upon claim 22 which is adapted for use with a thick film heating element having a track portion constituting, respectively, said adjustable resistance or said heater.

28. A liquid heating appliance including a control as claimed in any of claims 14 to 27.

29. A liquid heating appliance, or a control therefor, substantially as herein described with reference to Figure 1 or Figure 2 of the accompanying drawings.

30. A liquid heating appliance comprising a vessel, a heating element associated with said vessel, a normally-closed bimetallic cut-out in series with said heating element, said bimetallic cut-out being adapted to go open circuit at a predetermined liquid temperature below the boiling temperature of the liquid that is to be heated in the appliance, and a timer paralleling said cut-out for providing an alternative current supply path to the heating element for a predetermined limited time period, said timer being arranged to be initiated by operation of the cut-out.

31. A liquid heating appliance as claimed in claim 30 wherein the timer comprises a time current selected bimetallic cut-out.

32. A liquid heating appliance as claimed in claim 30 or 31 including an adjustable resistance in series with said time current selected bimetallic cut-out.

33. A liquid heating appliance as claimed in claim 30 or 31 or 32 including a normally open bimetallic switch in series with the heating element, said normally open bimetallic switch being manually closable to initiate operation of the heating element and thereafter holding itself in closed condition so long as current flows therethrough to the heating element.

34. A liquid heating appliance comprising a vessel, a main heating element associated with said vessel, an auxiliary heating element connected in series with a normally open bimetallic cut-out across said main heater, and a manually operable bimetallic switch determining the power supply to the heating element, said bimetallic cut-out being adapted to go closed circuit at a liquid temperature below the boiling point of the liquid that is to be heated in the appliance thereby to cause said auxiliary heating to be powered, and said bimetallic switch being controlled by said auxiliary heater so as to be caused to go open circuit a certain time period after said bimetallic cut-out goes closed circuit.

35. A liquid heating appliance as claimed in claim 34 wherein the degree of thermal contact between the auxiliary heater and the bimetallic switch is adjustable for adjusting said time period.

The Patent Office

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Application No: GB 0001906.7
Claims searched: 1-35

Examiner: Stephen Smith
Date of search: 5 June 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): A4A(AB2)

Int Cl (Ed.7): A47J 27/21

Other: ONLINE:EPODOC, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	WO 96/25869 A1 (PIFCO) lines 16-29 of page 6; lines 5-16 of page 8	1, 6, 11, 13, 14, 28

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.